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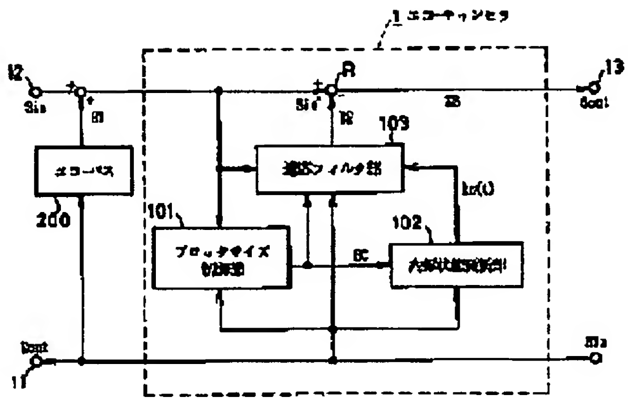
Abstract:
PROBLEM TO BE SOLVED: To reduce the arithmetic operation volume at initial stage of convergence by providing an adaptive filter part to generate a false echo signal, an inner state updating part, a block size control part to sequentially output to the adaptive filter part and an adder. SOLUTION: A far end input signal Rin and a near end input signal Sin are monitored by the block size control part 101 and an operation mode is decided from a relation between both signals. When initialization is performed, a tap number control signal BC whose value from the control part 101 shows 1 is outputted to an inner state updating part 102 and the adaptive filter part 103. The updating part 102 forms a gain vector and an inner state variable matrix at current time by a specified equation and a tap coefficient vector at current time in the filter part 103. And the false echo signal ER at current time is formed by the specific equation in the filter part 103 and an echo cancellation is performed in the adder R by subtracting the false echo signal ER.



JPO Machine translation abstract:

(57) **Abstract**

SUBJECT The operation amount at the time of initialization of adaptive operations is reduced. A tap coefficient is more quickly completed as the transfer characteristic of an echo path.

Means for Solution An input signal of a near end and a far edge, and an adaptation filter part which generates a false echo signal after presuming the transfer characteristic of an echo path from internal state quantity, The above-mentioned internal state quantity which has the number of elements required in order to presume the transfer characteristic of an echo path sequentially which becomes settled according to tap numbers is initialized, and it has an internal state updating section which updates internal state quantity, expanding the number of elements of internal state quantity one by one according to increase of tap numbers. When judging whether the echo canceller concerned is initialized and initializing, Set tap numbers as an initial value and expand tap numbers one by one after that, and the value is kept constant after tap numbers reach a number set up beforehand, It has a block size control section which outputs tap numbers which change in this way to an internal state updating section and an adaptation filter part, and an adding machine which subtracts a false echo signal from a near end input signal.

Claim(s)

Claim 1 An echo canceller comprising:

A near end input signal with which it is superimposed on an echo.

An far-end input signal only for tap numbers.

An adaptation filter part which presumes the transfer characteristic of an echo path in the time from internal state quantity, and generates a false echo signal by convolution arithmetic operation of the point estimate and the above-mentioned far-end input signal.

An internal state updating section which updates the above-mentioned internal state quantity which has the number of elements required in order to presume the transfer characteristic of an echo path sequentially which becomes settled according to tap numbers, and outputs updated

internal state quantity to the above-mentioned adaptation filter part, Judge whether the echo canceller concerned is initialized, and when initializing, Set tap numbers as an initial value and expand tap numbers one by one after that, and the value is kept constant after tap numbers reach a number set up beforehand, An adding machine which subtracts a block size control section which outputs tap numbers which change in this way one by one to the above-mentioned internal state updating section and the above-mentioned adaptation filter part, and a false echo signal outputted by the above-mentioned adaptation filter part from a near end input signal.

Claim 2 The echo canceller according to claim 1 which the above-mentioned adaptation filter part presumes the transfer characteristic of an echo path in accordance with an iterative least square technique, and is characterized by the above-mentioned internal state updating section updating internal state quantity in accordance with an iterative least square technique.

Detailed Description of the Invention
0001
Field of the Invention This invention relates to an echo canceller.
0002
Description of the Prior Art Generally for the circuit echo suppressor produced in the hybrid circuit in the transmission equipment which accommodated the international circuit etc., an echo canceller is used. The erasing quality of this echo canceller deteriorates by change of the transfer characteristic of an echo path, etc. For this reason, an adaptation filter with the good convergence characteristic which follows change of the transfer characteristic of an echo path at high speed, and generates a false echo signal is needed.
0003RLS (recursive least squares: successive-minima square) shown in the Kalman method or document 1 as a computational algorithm for such the convergence characteristic to realize a good adaptation filter -- there are law etc.
0004 Document 1 "Akira Sakai, "centering on the trend-RLS method of the latest adaptation algorithm -", 1992, Journal of the Acoustical Society of Japan 48 volume 7 No., and pp.493-500" Tap coefficient h' (k) (namely, h' (0) - h' (p)) such whose an adaptation filter is a point estimate of the transfer characteristic of the echo path from which it is obtained by far-end input signal x (n) and the RLS method By the convolution arithmetic operation shown in (1) type. False echo signal y (n) is generated. However, in (1) type, as for sigma, k expresses total from 0 to p (p+1 is tap numbers), and n expresses processing time.
0005
y (n) =sigmah' (k) x (n-k) -- (1)**0006**
Problem to be solved by the invention As mentioned above, in order to generate false echo signal y (n), with an adaptation filter, tap coefficient h' (k) which is a point estimate of the transfer characteristic of an echo path is needed. Here, in an adaptation filter, tap numbers must be determined according to the transfer characteristic (characteristic of an impulse response) of an echo path.
0007 However, since the transfer characteristic of the echo path which is the target of calculation is strange, the length of the impulse response of an echo path may be unable to be specified.
0008 In that case, although the fixed tap numbers beforehand estimated with a margin which covers the impulse response of an echo path will be used, generation data processing of a false echo signal may be performed by tap numbers longer than sometimes required tap numbers. In especially the initial stage of adaptive operations, although an input signal does not fully exist, the maximum calculation according to fixed tap numbers will be performed, and it sees from the field of computational complexity, and is not efficient.
0009 Although the high-speed convergence characteristic is shown and converging by repetition calculation of the less than twice of tap numbers is known, the repeat frequency for convergence also increases according to it, and, as a result, the RLS method must do a lot of operation, if the tap numbers of an adaptation filter become long.
0010 Therefore, in an initial stage of adaptive operations, to attain increase in efficiency of calculation for generation of a false echo signal is desired.

0011

Means for solving problem This invention is characterized by an echo canceller comprising the following, in order to solve this SUBJECT.
(1) A near end input signal with which it is superimposed on an echo.
An far-end input signal only for tap numbers.
An adaptation filter part which presumes the transfer characteristic of an echo path in the time from internal state quantity, and generates a false echo signal by convolution arithmetic operation of the point estimate and far-end input signal.
(2) An internal state updating section which updates internal state quantity which has the number of elements required in order to presume the transfer characteristic of an echo path sequentially which becomes settled according to tap numbers, and outputs updated internal state quantity to an adaptation filter part, (3) Judge whether the echo canceller concerned is initialized, and when initializing, Set tap numbers as an initial value and expand tap numbers one by one after that, and the value is kept constant after tap numbers reach a number set up beforehand, A block size control section which outputs tap numbers which change in this way one by one to an internal state updating section and an adaptation filter part, and (4) Adding machine which subtracts from a near end input signal a false echo signal outputted from an adaptation filter part

0012 By such composition, the operation amount at the time of the convergence operation first stage at the time of initializing an adaptation filter part can be reduced, and the high-speed convergence characteristic can be realized.

0013

Mode for carrying out the invention Hereafter, one embodiment of the echo canceller by this invention is explained in full detail, referring to Drawings.

0014 The RLS method is used for this embodiment as an updating algorithm of the point estimate of the transfer characteristic of an echo path. So, below, the theoretic updating method of various kinds of values by the RLS method is explained first.

0015 If ER is made into the false echo signal (echo replica) which is an output of an adaptation filter, false echo signal ER in the time t, (2) As shown in a formula, it is obtained by the convolution arithmetic operation of far-end input signal vector x_n (t) and tap coefficient vector h'_n (t) which is the point estimates of the transfer characteristic of an echo path. However, h'_n (t) is a n vector (column vector) in the time t, and x_n (t) is a column vector which consists of the time t with the sampled value of the far-end input signal by the n past. n is tap numbers of an adaptation filter part, and in the case of this embodiment, it has the feature for this tap-numbers n to change so that it may mention later.

0016

Mathematical formula 1

For drawings please refer to the original document.

In the RLS method, tap coefficient vector h'_n (t) which is a point estimate of the transfer characteristic of an echo path in the time t, Near end input signal **in the time t** (scalar quantity) y (t), and n dimension gain vector (column vector) $k_{n\ \textbf{in the time t}}$ (t), It is updated by a recurrence formula showing with far-end input signal vector x_n (t) in tap coefficient vector h'(3) from $_n$ (t-1) type in the time t-1.

0017

Mathematical formula 2

For drawings please refer to the original document.

Here n dimension gain vector $k_{n\ \textbf{in the time t}}$ (t), (4) As shown in a formula, it is sequentially updated by the oblivion coefficient (scalar quantity) lambda for making it influence it small as

internal state variable procession P_n (t-1) of n dimension in the time t-1, far-end input signal vector x_n (t), and the past information.

0018

Mathematical formula 3

For drawings please refer to the original document.

Internal state variable procession P_n (t) in the time t, (5) As shown in a formula, it is sequentially updated by far-end input signal x_n (t), gain vector k_n (t) in the time t and state-transition-matrix P_n (t-1) in the time t-1, and the recurrence formula using the oblivion coefficient lambda.

0019

Mathematical formula 4

For drawings please refer to the original document.

As mentioned above, in **so that clearly** the RLS method, If the time t is updated, gain vector k_n (t) will be updated according to (4) types, After updating tap coefficient vector h'_n (t) according to (3) types using updated gain vector k_n (t), according to (2) types, false echo signal ER of the time t concerned is formed using this updated tap coefficient vector h'_n (t). Internal state variable procession P_n (t) required for the renewal of gain vector k_n (t) in the next time is updated according to (5) types.

0020 Here, the vector and procession of the various kinds currently used by the (2) type - (5) formula mentioned above have a dimension which becomes settled in tap-numbers n of an adaptation filter part.

0021 In immediately after **at the time of redo of adaptive operations which in any cases are later mentioned in this embodiment although it was immobilization** , in the former, tap-numbers n of an adaptation filter part is made to carry out renewal of gradual increase of the tap-numbers n.Therefore, he is trying to also change various kinds of vectors and the dimension of a procession which are updated suitably according to change of tap-numbers n by the RLS method.

0022 In this embodiment, having made it change tap numbers is based on the following views.

0023 For example, when there is both an far-end input signal and nor a near end input signal neither, tap coefficient vector $h'_{n\ \textbf{of an adaptation filter part}}$ (t) is initialized, and adaptive operations are redone from the beginning. In this case, if various kinds of vectors and the operation of a procession are performed by fixed tap-numbers n (here, it is considered as n=p) like before, even when measurement sizes, such as an far-end input signal, will be less than p, the operation about the vector and procession of p dimension is performed. However, since a measurement size is less than p, naturally the element which takes the effective value of the vector and procession which are acquired as a result of an operation decreases. Thus, it can be said that it has much futility that they perform the operation of a vector or a procession as a dimension according to tap numbers although there are few elements which take an effective value. For example, in internal state variable procession P_n (t), there is an element of the square of tap-numbers p, although the operation according to this number of elements is required, immediately after initialization which redoes adaptive operations from the beginning, there are few elements of an effective value and many element operations are useless.

0024 So, at this embodiment, reduction of the operation amount is aimed at by expanding tap-numbers n used by an adaptation filter part one by one according to the effective measurement size after initialization, in redoing adaptive operations from the beginning.

0025 Drawing 1 is a block diagram showing the functional composition of the echo canceller of the embodiment made according to the above views.

0026 In drawing 1, the far-end input signal Rin inputted into the far-end input terminal 10 is inputted into the echo canceller 1 of this embodiment, and passes the echo canceller 1 and is given

to the processing circuit of the next step from the output terminal 11. It leaks and appears in the transmission line of the near end input signal Sin inputted from the near end input terminal 12 as echo ET via the echo path (it becomes by a hybrid circuit and others) 200, and the far-end input signal Rout (Rin) which passed the echo canceller 1 is superimposed by the near end input signal Sin. Near end input signal Sin' superimposed on such echo ET is inputted into the echo canceller 1 of this embodiment, an echo is eliminated, and the near end input signal Sout after elimination (residual signal ZS) is outputted from the terminal 13.

0027 The echo canceller 1 of the embodiment in the above input/output relation serves as the block size control section 101, the internal state updating section 102, and the adaptation filter part 103 from the adding machine R.

0028 The adaptation filter part 103 Near end input signal Sin' (=y (n)) of the current time t, Far-end input signal vector x_n (t) which becomes with the sampled value of the tap-numbers part p of the far-end input signal Rin, According to the tap coefficient vector h'(3) mentioned above from $_n$ (t-1) type of direct previous time, Tap coefficient vector $h'_{n\ \textbf{of the current time t}}$ (t) is formed (presuming the transfer characteristic of an echo path), and false echo signal ER is generated according to (2) types from the tap coefficient vector h'_n (t) and far-end input signal vector x_n (t).

0029 From the block size control section 101, tap-numbers control signal BC (=n) is given to this adaptation filter part 103, and it is made as **generate / tap coefficient vector $h'_{n/\ \text{of a dimension}\ /}$ (t) according to tap-numbers control signal BC (=n)** so that it may mention later. Here, when increasing a dimension, it is based on (8) types mentioned later.

0030 The far-end input signal Rin (far-end input signal vector x_n (t) which becomes with the sampled value of the tap-numbers part n) is inputted into the internal state updating section 102, and This far-end input signal vector x_n (t), From internal state variable procession P_n (t-1) and the oblivion coefficient (scalar quantity) lambda in the direct previous time t-1 which is carrying out internal possession. According to a formula, form gain vector $k_{n\ \textbf{in the current time t}}$ (t), and (4) Far-end input signal vector x_n (t), According to the oblivion coefficient lambda to updated gain vector k_n (t), state-transition-matrix P_n (t-1) in the direct previous time t-1, and (5) types, internal state variable procession P_n (t) in the current time t is formed. Internal possession of the gain vector $k_{n\ \textbf{in the formed current time t}}$ (t) and internal state variable procession P_n (t) is carried out at the internal state updating section 102 concerned, and gain vector k_n (t) is given to the adaptation filter part 103.

0031 So that it may mention later also to this internal state updating section 102 from the block size control section 101. Tap-numbers control signal BC (=n) is given, and it is made as **generate / gain vector $k_{n/\ \text{of a dimension}\ /}$ (t) according to tap-numbers control signal BC (=n), and internal state variable procession P_n (t)** . Here, when increasing the dimension of internal state variable procession P_n (t), it is based on (7) types mentioned later. Increase of the dimension of internal state variable procession P_n (t) and the dimension of far-end input signal vector x_n (t) will increase the dimension of gain vector k_n (t).

0032 The block size control section 101 judges whether far-end input signal Rin needs to reach, or it is necessary to initialize the echo canceller 1 concerned from the input state of near end input signal Sin' (in other words.). Various kinds of vector and procession h'_n (t) k_n (t) Judge the stage to initialize P_n (t), and when it is necessary to initialize, After making one initialize tap-numbers control signal BC (=n) which specifies tap numbers, Whenever the time t is updated, tap-numbers control signal BC is **************ed one time, and after tap-numbers control signal BC reaches maximum tap-numbers p set up beforehand, even if time passes, maximum tap-numbers p is made to maintain the value of tap-numbers control signal BC. As mentioned above, tap-numbers control signal BC updated with progress of time immediately after initialization is outputted to the internal state updating section 102 and the adaptation filter part 101.

0033 The adding machine R subtracts false echo signal ER from the adaptation filter part 103, and eliminates an echo from near end input signal Sin' superimposed on echo ET.

0034 Every time the echo canceller 1 of this embodiment that consists of above each part lets the whole pass, as shown in the flow chart of drawing 2, it operates. The processing loop in drawing 2 is processed once at each time.

0035 If the new time t comes, first, the far-end input signal Rin and near end input signal Sin' will be supervised by the block size control section 101, and operational mode will be judged from both relation, for example (Step S1). For example, it is judged whether the adaptive operations which generate false echo signal ER are initialized by whether it is in the situation (situation where a sound level is not reached) where the fixed time input of either an far-end input signal and a near end input signal or both signals is not carried out.

0036 In initializing, from the block size control section 101, it is outputted to the internal state updating section 102 and the adaptation filter part 103 by tap-numbers control signal BC (=n) whose value is 1, and At this time. The internal state updating section 102 sets internal state variable procession P_n (t-1) of the direct previous time t-1 as the procession of 1x1 which has only initial parameter alpha (fixed value), as shown in (6) types (Step S2).

0037

P_n (t-1) =alpha -- When the result that initialization is unnecessary is obtained by (6), on the other hand judgment of Step S1, the block size control section 101, Check whether old tap-numbers control signal BC (=n) has already reached maximum tap-numbers p, and if it has not reached, If tap-numbers control signal BC (=n) which **************ed one time was outputted to the internal state updating section 102 and the adaptation filter part 103, expanding processing of the dimension was performed and maximum tap-numbers p is reached on the other hand, Tap-numbers control signal BC (=n) of maximum tap-numbers p is outputted to the internal state updating section 102 and the adaptation filter part 103, and it is made not to make the expanding processing of a dimension perform (Step S3).

0038 The internal state updating section 102 to which tap-numbers control signal BC (=n) which it **************ed one time was given here, According to (7) types, internal state variable procession P_n (t-1) of the direct previous time t-1, According to (8) types, as for the adaptation filter part 103 to which tap-numbers control signal BC (=n) by which the dimension updated in procession only with 1 **large** , and it **************ed it one time was given, a dimension updates tap coefficient vector h'_n (t-1) of the direct previous time t-1 in procession only with 1 **large** .

0039

Mathematical formula 5

For drawings please refer to the original document.

Then, according to (4) types and (5) types which were mentioned above, gain vector $k_{n\ \textbf{in the current time t}}$ (t) and internal state variable procession P_n (t) is formed of the internal state updating section 102 regardless of the existence of execution of expansion operation of a dimension (step S4). Then, in the adaptation filter part 103, tap coefficient vector $h'_{n\ \textbf{in the current time t}}$ (t) is formed according to (3) types mentioned above (Step S5). Naturally the dimension of far-end input signal vector x_n (t) used at the time of these data processing is also depended on the value of tap-numbers control signal BC at that time (=n).

0040 And in the adaptation filter part 103, according to (2) types mentioned above, false echo signal ER in the current time t is formed, and echo suppressor operation by subtraction of false echo signal ER is performed in the adding machine R (Step S6).

0041 Thus, after a series of processings in the current time t are completed, it will return to Step S1 and will progress to processing of the next time (t=t+1).

0042 When initialization is needed by processing shown in above drawing 2, Effective tap numbers perform the adaptive operations of 1 (S1, S2, S4-S6), then -- performing the adaptive operations which increased effective tap numbers every **1** for every time until it reached maximum tap-numbers p (S1 and S3 (accompanied by renewal of tap numbers).) After reaching S4-S6 and maximum tap-numbers p, the adaptive operations in the tap-numbers p are performed (S1, S3

(tap numbers are not updated), S4-S6).
0043 Since it was made to make tap numbers increase from the initialization start time which redoes adaptive operations again one by one about operation of an internal state updating section and an adaptation filter part according to the above-mentioned embodiment, the operation amount at the time of initialization of adaptive operations refollowed to the transfer characteristic of an echo path is reducible.
0044 When an impulse response of an echo path is comparatively short, even if it reduces an operation amount in this way, a tap coefficient can be more quickly completed as the transfer characteristic of an echo path.
0045 Various parameters, such as a tap coefficient of an adaptation filter part, can realize prompt convergence operation, without disrupting convergence operation, since it is succeeded to the next time also when tap numbers are increased.
0046 Although an echo canceller applied to the RLS method was shown in the above-mentioned embodiment, This invention is applicable if it is the echo canceller which has adopted an algorithm which forms a tap coefficient (vector) using internal state quantity which is expressed with a vector which has a dimension according to tap numbers, a procession, etc., and which is updated one by one for every time. For example, this invention is applicable to an echo canceller using the Kalman-filter method, a learning-identification method, etc.
0047 In the above-mentioned embodiment, although an echo canceller which eliminates an echo by impedance mismatching of a hybrid circuit is assumed, this invention is applicable to an echo canceller which eliminates from a loudspeaker an echo around which it turned to a microphone.
0048
Effect of the Invention As mentioned above, since it was made to make tap numbers increase from the initialization start time which redoes adaptive operations again one by one about operation of an internal state updating section and an adaptation filter part according to this invention, The operation amount at the time of initialization of adaptive operations refollowed to the transfer characteristic of an echo path is reducible, and when the impulse response of an echo path is comparatively short, a tap coefficient can be more quickly completed as the transfer characteristic of an echo path.

Field of the Invention This invention relates to an echo canceller.

Description of the Prior Art Generally for the circuit echo suppressor produced in the hybrid circuit in the transmission equipment which accommodated the international circuit etc., an echo canceller is used. The erasing quality of this echo canceller deteriorates by change of the transfer characteristic of an echo path, etc. For this reason, an adaptation filter with the good convergence characteristic which follows change of the transfer characteristic of an echo path at high speed, and generates a false echo signal is needed.
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0004 Document 1 "Akira Sakai, "centering on the trend-RLS method of the latest adaptation algorithm -", 1992, Journal of the Acoustical Society of Japan 48 volume 7 No., and pp.493-500" Tap coefficient h' (k) (namely, h' (0) - h' (p)) such whose an adaptation filter is a point estimate of the transfer characteristic of the echo path from which it is obtained by far-end input signal x (n) and the RLS method By the convolution arithmetic operation shown in (1) type. False echo signal y (n) is generated. However, in (1) type, as for sigma, k expresses total from 0 to p (p+1 is tap numbers), and n expresses processing time.
0005
y (n) =sigmah' (k) x (n-k) -- (1)

Effect of the Invention As mentioned above, since it was made to make tap numbers increase from the initialization start time which redoes adaptive operations again one by one about operation of an internal state updating section and an adaptation filter part according to this invention, The operation amount at the time of initialization of adaptive operations refollowed to the transfer characteristic of an echo path is reducible, and when the impulse response of an echo path is comparatively short, a tap coefficient can be more quickly completed as the transfer characteristic of an echo path.

Problem to be solved by the invention As mentioned above, in order to generate false echo signal y (n), with an adaptation filter, tap coefficient h' (k) which is a point estimate of the transfer characteristic of an echo path is needed. Here, in an adaptation filter, tap numbers must be determined according to the transfer characteristic (characteristic of an impulse response) of an echo path.
0007 However, since the transfer characteristic of the echo path which is the target of calculation is strange, the length of the impulse response of an echo path may be unable to be specified.
0008 In that case, although the fixed tap numbers beforehand estimated with a margin which covers the impulse response of an echo path will be used, generation data processing of a false echo signal may be performed by tap numbers longer than sometimes required tap numbers. In especially the initial stage of adaptive operations, although an input signal does not fully exist, the maximum calculation according to fixed tap numbers will be performed, and it sees from the field of computational complexity, and is not efficient.
0009 Although the high-speed convergence characteristic is shown and converging by repetition calculation of the less than twice of tap numbers is known, the repeat frequency for convergence also increases according to it, and, as a result, the RLS method must do a lot of operation, if the tap numbers of an adaptation filter become long.
0010 Therefore, in the initial stage of adaptive operations, to attain the increase in efficiency of calculation for generation of a false echo signal is desired.

Means for solving problem This invention is characterized by an echo canceller comprising the following, in order to solve this SUBJECT.
(1) The near end input signal with which it is superimposed on the echo.
The far-end input signal only for tap numbers.
The adaptation filter part which presumes the transfer characteristic of the echo path in the time from internal state quantity, and generates a false echo signal by the convolution arithmetic operation of the point estimate and far-end input signal.
(2) The internal state updating section which updates the internal state quantity which has the number of elements required in order to presume the transfer characteristic of an echo path sequentially which becomes settled according to tap numbers, and outputs the updated internal state quantity to an adaptation filter part, (3) Judge whether the echo canceller concerned is initialized, and when initializing, Set tap numbers as an initial value and expand tap numbers one by one after that, and the value is kept constant after tap numbers reach the number set up beforehand, The block size control section which outputs the tap numbers which change in this way one by one to an internal state updating section and an adaptation filter part, and (4) Adding machine which subtracts from a near end input signal the false echo signal outputted from the adaptation filter part

0012 By such composition, the operation amount at the time of the convergence operation first stage at the time of initializing an adaptation filter part can be reduced, and the high-speed convergence characteristic can be realized.
0013
Mode for carrying out the invention Hereafter, one embodiment of the echo canceller by this invention is explained in full detail, referring to Drawings.

0014 The RLS method is used for this embodiment as an updating algorithm of the point estimate of the transfer characteristic of an echo path. So, below, the theoretic updating method of various kinds of values by the RLS method is explained first.
0015 If ER is made into the false echo signal (echo replica) which is an output of an adaptation filter, false echo signal ER in the time t, (2) As shown in a formula, it is obtained by the convolution arithmetic operation of far-end input signal vector x_n (t) and tap coefficient vector h'_n (t) which is the point estimates of the transfer characteristic of an echo path. However, h'_n (t) is a n vector (column vector) in the time t, and x_n (t) is a column vector which consists of the time t with the sampled value of the far-end input signal by the n past. n is tap numbers of an adaptation filter part, and in the case of this embodiment, it has the feature for this tap-numbers n to change so that it may mention later.
0016
Mathematical formula 1

For drawings please refer to the original document.

In the RLS method, tap coefficient vector h'_n (t) which is a point estimate of the transfer characteristic of the echo path in the time t, Near end input signal **in the time t** (scalar quantity) y (t), and n dimension gain vector (column vector) $k_{n\ \textbf{in the time t}}$ (t), It is updated by the recurrence formula showing with far-end input signal vector x_n (t) in the tap coefficient vector h'(3) from $_n$ (t-1) type in the time t-1.
0017
Mathematical formula 2

For drawings please refer to the original document.

Here n dimension gain vector $k_{n\ \textbf{in the time t}}$ (t), (4) As shown in a formula, it is sequentially updated by the oblivion coefficient (scalar quantity) lambda for making it influence it small as internal state variable procession P_n (t-1) of n dimension in the time t-1, far-end input signal vector x_n (t), and the past information.
0018
Mathematical formula 3

For drawings please refer to the original document.

Internal state variable procession P_n (t) in the time t, (5) As shown in a formula, it is sequentially updated by far-end input signal x_n (t), gain vector k_n (t) in the time t and state-transition-matrix P_n (t-1) in the time t-1, and the recurrence formula using the oblivion coefficient lambda.
0019
Mathematical formula 4

For drawings please refer to the original document.

As mentioned above, in **so that clearly** the RLS method, If the time t is updated, gain vector k_n (t) will be updated according to (4) types, After updating tap coefficient vector h'_n (t) according to (3) types using updated gain vector k_n (t), according to (2) types, false echo signal ER of the time t concerned is formed using this updated tap coefficient vector h'_n (t). Internal state variable procession P_n (t) required for the renewal of gain vector k_n (t) in the next time is updated

according to (5) types.
0020 Here, the vector and procession of the various kinds currently used by the (2) type - (5) formula mentioned above have a dimension which becomes settled in tap-numbers n of an adaptation filter part.
0021 In immediately after **at the time of redo of adaptive operations which in any cases are later mentioned in this embodiment although it was immobilization** , in the former, tap-numbers n of an adaptation filter part is made to carry out renewal of gradual increase of the tap-numbers n.Therefore, he is trying to also change various kinds of vectors and the dimension of a procession which are updated suitably according to change of tap-numbers n by the RLS method.
0022 In this embodiment, having made it change tap numbers is based on the following views.
0023 For example, when there is both an far-end input signal and nor a near end input signal neither, tap coefficient vector $h'_{n\ \textbf{of an adaptation filter part}}$ (t) is initialized, and adaptive operations are redone from the beginning. In this case, if various kinds of vectors and the operation of a procession are performed by fixed tap-numbers n (here, it is considered as n=p) like before, even when measurement sizes, such as an far-end input signal, will be less than p, the operation about the vector and procession of p dimension is performed. However, since a measurement size is less than p, naturally the element which takes the effective value of the vector and procession which are acquired as a result of an operation decreases. Thus, it can be said that it has much futility that they perform the operation of a vector or a procession as a dimension according to tap numbers although there are few elements which take an effective value. For example, in internal state variable procession P_n (t), there is an element of the square of tap-numbers p, although the operation according to this number of elements is required, immediately after initialization which redoes adaptive operations from the beginning, there are few elements of an effective value and many element operations are useless.
0024 So, at this embodiment, reduction of the operation amount is aimed at by expanding tap-numbers n used by an adaptation filter part one by one according to the effective measurement size after initialization, in redoing adaptive operations from the beginning.
0025 Drawing 1 is a block diagram showing the functional composition of the echo canceller of the embodiment made according to the above views.
0026 In drawing 1, the far-end input signal Rin inputted into the far-end input terminal 10 is inputted into the echo canceller 1 of this embodiment, and passes the echo canceller 1 and is given to the processing circuit of the next step from the output terminal 11. It leaks and appears in the transmission line of the near end input signal Sin inputted from the near end input terminal 12 as echo ET via the echo path (it becomes by a hybrid circuit and others) 200, and the far-end input signal Rout (Rin) which passed the echo canceller 1 is superimposed by the near end input signal Sin. Near end input signal Sin' superimposed on such echo ET is inputted into the echo canceller 1 of this embodiment, an echo is eliminated, and the near end input signal Sout after elimination (residual signal ZS) is outputted from the terminal 13.
0027 The echo canceller 1 of an embodiment in the above input/output relation serves as the block size control section 101, the internal state updating section 102, and the adaptation filter part 103 from the adding machine R.
0028 The adaptation filter part 103 Near end input signal Sin' (=y (n)) of the current time t, Far-end input signal vector x_n (t) which becomes with a sampled value of the tap-numbers part p of the far-end input signal Rin, According to tap coefficient vector h'(3) mentioned above from $_n$ (t-1) type of direct previous time, Tap coefficient vector $h'_{n\ \textbf{of the current time t}}$ (t) is formed (presuming the transfer characteristic of an echo path), and false echo signal ER is generated according to (2) types from the tap coefficient vector h'_n (t) and far-end input signal vector x_n (t).
0029 From the block size control section 101, tap-numbers control signal BC (=n) is given to this adaptation filter part 103, and it is made as **generate / tap coefficient vector** $h'_{n/\ \textbf{of a dimension}\ /}$ **(t) according to tap-numbers control signal BC (=n)** so that it may mention later. Here, when increasing a dimension, it is based on (8) types mentioned later.
0030 The far-end input signal Rin (far-end input signal vector x_n (t) which becomes with a sampled value of the tap-numbers part n) is inputted into the internal state updating section 102, and This

far-end input signal vector x_n (t), From internal state variable procession P_n (t-1) and the oblivion coefficient (scalar quantity) lambda in the direct previous time t-1 which is carrying out internal possession. According to a formula, form gain vector k_n **in the current time t** (t), and (4) Far-end input signal vector x_n (t), According to the oblivion coefficient lambda to updated gain vector k_n (t), state-transition-matrix P_n (t-1) in the direct previous time t-1, and (5) types, internal state variable procession P_n (t) in the current time t is formed. Internal possession of the gain vector k_n **in the formed current time t** (t) and internal state variable procession P_n (t) is carried out at the internal state updating section 102 concerned, and gain vector k_n (t) is given to the adaptation filter part 103.

0031 So that it may mention later also to this internal state updating section 102 from the block size control section 101. Tap-numbers control signal BC (=n) is given, and it is made as **generate / gain vector $k_{n/\text{ of a dimension }/}$ (t) according to tap-numbers control signal BC (=n), and internal state variable procession P_n (t)** . Here, when increasing the dimension of internal state variable procession P_n (t), it is based on (7) types mentioned later. Increase of the dimension of internal state variable procession P_n (t) and the dimension of far-end input signal vector x_n (t) will increase the dimension of gain vector k_n (t).

0032 The block size control section 101 judges whether far-end input signal Rin needs to reach, or it is necessary to initialize the echo canceller 1 concerned from the input state of near end input signal Sin' (in other words.). Various kinds of vector and procession h'_n (t) k_n (t) Judge the stage to initialize P_n (t), and when it is necessary to initialize, After making one initialize tap-numbers control signal BC (=n) which specifies tap numbers, Whenever the time t is updated, tap-numbers control signal BC is **************ed one time, and after tap-numbers control signal BC reaches maximum tap-numbers p set up beforehand, even if time passes, maximum tap-numbers p is made to maintain the value of tap-numbers control signal BC. As mentioned above, tap-numbers control signal BC updated with progress of time immediately after initialization is outputted to the internal state updating section 102 and the adaptation filter part 101.

0033 The adding machine R subtracts false echo signal ER from the adaptation filter part 103, and eliminates an echo from near end input signal Sin' superimposed on echo ET.

0034 Every time the echo canceller 1 of this embodiment that consists of above each part lets the whole pass, as shown in a flow chart of drawing 2, it operates. A processing loop in drawing 2 is processed once at each time.

0035 If the new time t comes, first, the far-end input signal Rin and near end input signal Sin' will be supervised by the block size control section 101, and operational mode will be judged from both relation, for example (Step S1). For example, it is judged whether adaptive operations which generate false echo signal ER are initialized by whether it is in a situation (situation where a sound level is not reached) where the fixed time input of either an far-end input signal and a near end input signal or both signals is not carried out.

0036 In initializing, from the block size control section 101, it is outputted to the internal state updating section 102 and the adaptation filter part 103 by tap-numbers control signal BC (=n) whose value is 1, and At this time. The internal state updating section 102 sets internal state variable procession P_n (t-1) of the direct previous time t-1 as the procession of 1x1 which has only initial parameter alpha (fixed value), as shown in (6) types (Step S2).

0037

P_n (t-1) =alpha -- When the result that initialization is unnecessary is obtained by (6), on the other hand judgment of Step S1, the block size control section 101, Check whether old tap-numbers control signal BC (=n) has already reached maximum tap-numbers p, and if it has not reached, If tap-numbers control signal BC (=n) which **************ed one time was outputted to the internal state updating section 102 and the adaptation filter part 103, expanding processing of the dimension was performed and maximum tap-numbers p is reached on the other hand, Tap-numbers control signal BC (=n) of maximum tap-numbers p is outputted to the internal state updating section 102 and the adaptation filter part 103, and it is made not to make the expanding

processing of a dimension perform (Step S3).
0038 The internal state updating section 102 to which tap-numbers control signal BC (=n) which it **************ed one time was given here, According to (7) types, internal state variable procession P_n (t-1) of the direct previous time t-1, According to (8) types, as for the adaptation filter part 103 to which tap-numbers control signal BC (=n) by which the dimension updated in procession only with 1 **large** , and it **************ed it one time was given, a dimension updates tap coefficient vector h'_n (t-1) of the direct previous time t-1 in procession only with 1 **large** .
0039
Mathematical formula 5

For drawings please refer to the original document.

Then, according to (4) types and (5) types which were mentioned above, gain vector k_n **in the current time t** (t) and internal state variable procession P_n (t) is formed of the internal state updating section 102 regardless of the existence of execution of expansion operation of a dimension (step S4). Then, in the adaptation filter part 103, tap coefficient vector h'_n **in the current time t** (t) is formed according to (3) types mentioned above (Step S5). Naturally the dimension of far-end input signal vector x_n (t) used at the time of these data processing is also depended on the value of tap-numbers control signal BC at that time (=n).
0040 And in the adaptation filter part 103, according to (2) types mentioned above, false echo signal ER in the current time t is formed, and echo suppressor operation by subtraction of false echo signal ER is performed in the adding machine R (Step S6).
0041 Thus, after a series of processings in the current time t are completed, it will return to Step S1 and will progress to processing of the next time (t=t+1).
0042 When initialization is needed by processing shown in above drawing 2, Effective tap numbers perform the adaptive operations of 1 (S1, S2, S4-S6), then -- performing the adaptive operations which increased effective tap numbers every **1** for every time until it reached maximum tap-numbers p (S1 and S3 (accompanied by renewal of tap numbers).) After reaching S4-S6 and maximum tap-numbers p, the adaptive operations in the tap-numbers p are performed (S1, S3 (tap numbers are not updated), S4-S6).
0043 Since it was made to make tap numbers increase from the initialization start time which redoes adaptive operations again one by one about operation of an internal state updating section and an adaptation filter part according to the above-mentioned embodiment, the operation amount at the time of initialization of adaptive operations refollowed to the transfer characteristic of an echo path is reducible.
0044 When the impulse response of an echo path is comparatively short, even if it reduces an operation amount in this way, a tap coefficient can be more quickly completed as the transfer characteristic of an echo path.
0045 Various parameters, such as a tap coefficient of an adaptation filter part, can realize prompt convergence operation, without disrupting convergence operation, since it is succeeded to the next time also when tap numbers are increased.
0046 Although the echo canceller applied to the RLS method was shown in the above-mentioned embodiment, This invention is applicable if it is the echo canceller which has adopted the algorithm which forms a tap coefficient (vector) using the internal state quantity which is expressed with the vector which has a dimension according to tap numbers, a procession, etc., and which is updated one by one for every time. For example, this invention is applicable to the echo canceller using the Kalman-filter method, a learning-identification method, etc.
0047 In the above-mentioned embodiment, although the echo canceller which eliminates the echo by the impedance mismatching of a hybrid circuit is assumed, this invention is applicable to the echo canceller which eliminates from a loudspeaker the echo around which it turned to the microphone.

Brief Description of the Drawings
Drawing 1 It is a functional block diagram showing the composition of an embodiment.
Drawing 2 It is the flow chart which showed operation of the embodiment.
Explanations of letters or numerals
1 **-- An adaptation filter part, R / -- Adding machine.** -- An echo canceller, 101 -- A block size control section, 102 -- An internal state updating section, 103

Drawing 1

For drawings please refer to the original document.

Drawing 2

For drawings please refer to the original document.

For drawings please refer to the original document.

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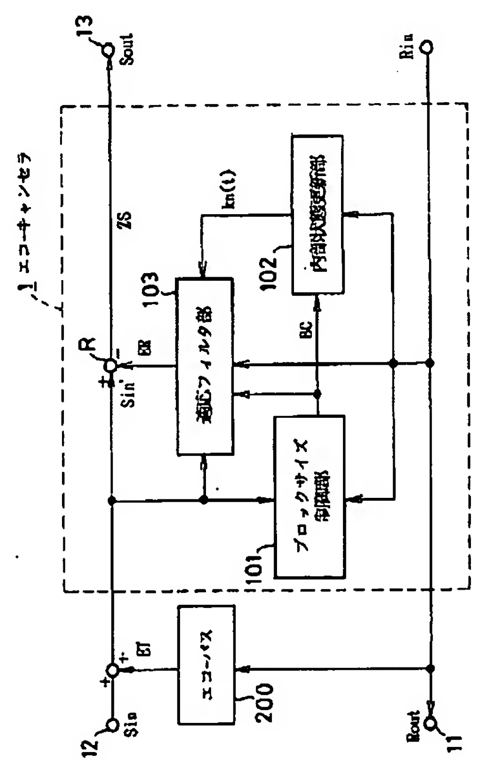
(54)【発明の名称】　エコーキャンセラ

(57)【要約】
【課題】　適応動作の初期化時における演算量を削減する。タップ係数をより速くエコーパスの伝達特性に収束させる。
【解決手段】　近端及び遠端の入力信号と、内部状態量とからエコーパスの伝達特性を推定した後、疑似エコー信号を生成する適応フィルタ部と、エコーパスの伝達特性を逐次的に推定するために必要な、タップ数に応じて定まる要素数を有する上記内部状態量を初期化し、タップ数の増大に応じて内部状態量の要素数を逐次拡大しつつ内部状態量を更新する内部状態更新部とを有する。また、当該エコーキャンセラを初期化するか否かを判断し、初期化する場合に、タップ数を初期値に設定し、その後タップ数を逐次拡大し、予め設定された数にタップ数が達した後はその値を一定に保ち、このように変化するタップ数を内部状態更新部及び適応フィルタ部へ出力するブロックサイズ制御部と、近端入力信号から疑似エコー信号を減算する加算器とを有する。



【特許請求の範囲】

【請求項１】　エコーが重畳されている近端入力信号と、タップ数分だけの遠端入力信号と、内部状態量とからその時刻におけるエコーパスの伝達特性を推定し、その推定値と上記遠端入力信号との畳み込み演算によって疑似エコー信号を生成する適応フィルタ部と、
エコーパスの伝達特性を逐次的に推定するために必要な、タップ数に応じて定まる要素数を有する上記内部状態量を更新し、更新された内部状態量を上記適応フィルタ部へ出力する内部状態更新部と、
当該エコーキャンセラを初期化するか否かを判断し、初期化する場合に、タップ数を初期値に設定し、その後タップ数を逐次拡大し、予め設定された数にタップ数が達した後はその値を一定に保ち、このように変化するタップ数を上記内部状態更新部及び上記適応フィルタ部へ逐次出力するブロックサイズ制御部と、
近端入力信号から上記適応フィルタ部から出力された疑似エコー信号を減算する加算器とを有することを特徴とするエコーキャンセラ。

【請求項２】　上記適応フィルタ部が、エコーパスの伝達特性を逐次最小２乗法に従って推定すると共に、上記内部状態更新部が、逐次最小２乗法に従って内部状態量を更新することを特徴とする請求項１に記載のエコーキャンセラ。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、エコーキャンセラに関するものである。

【０００２】

【従来の技術】国際回線などを収容した伝送装置におけるハイブリッド回路で生ずる回線エコー消去のために、一般にはエコーキャンセラが用いられる。このエコーキャンセラの消去特性は、エコーパスの伝達特性の変動などによって劣化する。このため、エコーパスの伝達特性の変動に高速に追従して疑似エコー信号を生成する収束特性が良好な適応フィルタが必要となる。

【０００３】このような収束特性が良好な適応フィルタを実現するための計算アルゴリズムとして、カルマン法や文献１に示すＲＬＳ（recursive least squares:逐次最小２乗）法などがある。

【０００４】文献１『酒井著、「最近の適応アルゴリズムの動向－ＲＬＳ法を中心として－」、１９９２、日本音響学会誌４８巻７号、pp.493-500』
このような適応フィルタは、遠端入力信号ｘ(n) と、ＲＬＳ法によって得られるエコーパスの伝達特性の推定値であるタップ係数ｈ’(k) （すなわちｈ’(0)～ｈ’(p)）との(1) 式に示す畳み込み演算によって、疑似エコー信号ｙ(n) を生成するものである。但し、(1) 式において、Σはｋが０からｐ（ｐ＋１がタップ数）までの総和を表しており、ｎは処理時刻を表している。

【０００５】

$$y(n) = \Sigma h'(k)\ x(n-k) \qquad \cdots(1)$$

【０００６】

【発明が解決しようとする課題】以上のように、疑似エコー信号ｙ(n) を発生させるために、適応フィルタではエコーパスの伝達特性の推定値であるタップ係数ｈ’(k) が必要となる。ここで、適応フィルタでは、エコーパスの伝達特性（インパルス応答の特性）に応じてタップ数を決定しなければならない。

【０００７】しかし、計算の対象となるエコーパスの伝達特性は未知なので、エコーパスのインパルス応答の長さが特定できない場合がある。

【０００８】その場合、エコーパスのインパルス応答をカバーするような余裕をもって予め見積もった固定的なタップ数を利用することになるが、時として必要なタップ数よりも長いタップ数で、疑似エコー信号の生成演算処理が行なわれる可能性がある。特に適応動作の初期段階においては、入力信号が十分に存在しないにもかかわらず、固定タップ数に応じた最大限の計算を行なうことになり、計算量の面から見て効率的でない。

【０００９】また、ＲＬＳ法は、高速な収束特性を示し、タップ数の２倍以内の繰り返し計算で収束することが知られているが、適応フィルタのタップ数が長くなると、それに応じて収束のための繰り返し回数も増大し、その結果、大量の演算をしなければならなくなる。

【００１０】そのため、適応動作の初期段階において、疑似エコー信号の生成のための計算の効率化を図ることが望まれている。

【００１１】

【課題を解決するための手段】かかる課題を解決するために、本発明のエコーキャンセラは、(1) エコーが重畳されている近端入力信号と、タップ数分だけの遠端入力信号と、内部状態量とからその時刻におけるエコーパスの伝達特性を推定し、その推定値と遠端入力信号との畳み込み演算によって疑似エコー信号を生成する適応フィルタ部と、(2)エコーパスの伝達特性を逐次的に推定するために必要な、タップ数に応じて定まる要素数を有する内部状態量を更新し、更新された内部状態量を適応フィルタ部へ出力する内部状態更新部と、(3) 当該エコーキャンセラを初期化するか否かを判断し、初期化する場合に、タップ数を初期値に設定し、その後タップ数を逐次拡大し、予め設定された数にタップ数が達した後はその値を一定に保ち、このように変化するタップ数を内部状態更新部及び適応フィルタ部へ逐次出力するブロックサイズ制御部と、(4) 近端入力信号から適応フィルタ部から出力された疑似エコー信号を減算する加算器とを有することを特徴とする。

【００１２】このような構成により、適応フィルタ部を

初期化した際の収束動作初期時の演算量を削減でき、高速な収束特性を実現できる。

【0013】

【発明の実施の形態】以下、本発明によるエコーキャンセラの一実施形態を図面を参照しながら詳述する。

【0014】この実施形態は、エコーパスの伝達特性の推定値の更新アルゴリズムとしてＲＬＳ法を用いたものである。そこで、以下ではまず、ＲＬＳ法による各種の値の原理的な更新方法を説明する。

【0015】ＥＲを適応フィルタの出力である疑似エコー信号（エコーレプリカ）とすると、時刻ｔにおける疑似エコー信号ＥＲは、(2) 式に示すように、遠端入力信号ベクトルx_n (t) と、エコーパスの伝達特性の推定値であるタップ係数ベクトルh'_n (t) との畳み込み演算によって得られる。但し、h'_n (t) は時刻ｔにおけるｎ次元ベクトル（縦ベクトル）であり、x_n (t) は時刻ｔから過去ｎ個までの遠端入力信号のサンプル値でなる縦ベクトルである。また、ｎは、適応フィルタ部のタップ数であり、この実施形態の場合、後述するように、このタップ数ｎが変化することに特徴を有するものである。

【0016】

【数1】

$$ER = h'^{T}_{n}(t)\,x_{n}(t) \qquad \text{--- (2)}$$

ＲＬＳ法においては、時刻ｔにおけるエコーパスの伝達特性の推定値であるタップ係数ベクトルh'_n (t) は、時刻ｔでの近端入力信号（スカラー量）ｙ(t)と、時刻ｔでのｎ次元ゲインベクトル（縦ベクトル）k_n (t) と、遠端入力信号ベクトルx_n (t) と、時刻ｔ－１でのタップ係数ベクトルh'_n (t-1) とから、(3) 式に示す漸化式によって更新されるものである。

【0017】

【数2】

$$h'_n(t) = h'_n(t-1) + k_n(t)\left(y(t) - x_n{}^{T}(t)h'_n(t-1)\right) \qquad \text{--- (3)}$$

ここで、時刻ｔでのｎ次元ゲインベクトルk_n (t) は、(4) 式に示すように、時刻ｔ－１におけるｎ次元の内部状態変数行列P_n(t-1) と、遠端入力信号ベクトルx_n (t) と、過去の情報ほど影響を小さくさせるための忘却係数（スカラー量）λによって逐次的に更新されるものである。

【0018】

【数3】

$$k_n(t) = \frac{P_n(t-1)x_n(t)}{\lambda + x_n{}^{T}(t)P_n(t-1)x_n(t)} \qquad \text{--- (4)}$$

また、時刻ｔにおける内部状態変数行列P_n (t) は、(5) 式に示すように、遠端入力信号x_n (t) と、時刻ｔにおけるゲインベクトルk_n (t) と、時刻ｔ－１における状態遷移行列P_n (t-1) と、忘却係数λを用いた漸化式によって逐次的に更新されるものである。

【0019】

【数4】

$$P_n(t) = \frac{1}{\lambda}\left(P_n(t-1) - k_n(t)x_n{}^{T}(t)P_n(t-1)\right) \qquad \text{--- (5)}$$

以上から明らかなように、ＲＬＳ法においては、時刻ｔが更新されると、(4)式に従って、ゲインベクトルk_n (t) を更新し、更新されたゲインベクトルk_n(t) をも用いて、(3) 式に従って、タップ係数ベクトルh'_n (t) を更新した後、この更新されたタップ係数ベクトルh'_n (t) をも用いて、(2) 式に従って、当該時刻ｔの疑似エコー信号ＥＲを形成する。また、次の時刻におけるゲインベクトルk_n (t) の更新に必要な内部状態変数行列P_n (t) を(5) 式に従って更新しておく。

【0020】ここで、上述した(2) 式～(5) 式で使用されている各種のベクトルや行列は、適応フィルタ部のタップ数ｎで定まる次元を有するものである。

【0021】従来においては、適応フィルタ部のタップ数ｎはいかなる場合にも固定であったが、この実施形態においては、後述するような適応動作のやり直し時の直後の場合には、タップ数ｎを漸増更新させるようにしている。従って、ＲＬＳ法によって適宜更新される各種のベクトルや行列の次元も、タップ数ｎの変化に応じて変化させるようにしている。

【0022】この実施形態において、タップ数を変化させるようにしたのは、以下の考え方による。

【0023】例えば、遠端入力信号や近端入力信号が共にないような場合には、適応フィルタ部のタップ係数ベクトルh'_n (t) を初期化して適応動作を最初からやり直す。この場合において、従来のように、固定タップ数ｎ（ここではｎ＝ｐとする）で各種のベクトルや行列の演算を行なうと、遠端入力信号等のサンプル数がｐに満たない場合でも、ｐ次元のベクトルや行列についての演算を行なう。しかし、サンプル数がｐに満たないので、演算の結果得られるベクトルや行列の有効な値をとる要素は当然に少なくなる。このように有効な値をとる要素が、少ないにも拘らず、タップ数に応じた次元として、

ベクトルや行列の演算を行なうことは無駄が多いということができる。例えば、内部状態変数行列P_n（t）では、タップ数pの2乗の要素があり、この要素数に応じた演算が必要であるが、適応動作を最初からやり直す初期化直後においては、有効な値の要素が少なく、多くの要素演算が無駄になっている。

【0024】そこで、この実施形態では、適応フィルタ部で用いるタップ数nを、適応動作を最初からやり直す場合には、初期化後の有効サンプル数に応じて順次拡大するようにすることで演算量の削減を図っている。

【0025】図1は、以上のような考え方に従ってなされた実施形態のエコーキャンセラの機能的構成を示すブロック図である。

【0026】図1において、遠端入力端子10に入力された遠端入力信号Ｒｉｎは、この実施形態のエコーキャンセラ1に入力されると共に、エコーキャンセラ1を通過して出力端子11から次段の処理回路に与えられる。エコーキャンセラ1を通過した遠端入力信号Ｒｏｕｔ（Ｒｉｎ）は、エコーパス（ハイブリッド回路その他でなる）200を介して、エコーＥＴとして、近端入力端子12から入力された近端入力信号Ｓｉｎの伝送ラインに漏れでて、近端入力信号Ｓｉｎに重畳される。このようなエコーＥＴが重畳された近端入力信号Ｓｉｎ’が、この実施形態のエコーキャンセラ1に入力されてエコーが消去され、消去後の近端入力信号Ｓｏｕｔ（残差信号ＺＳ）が端子13から出力される。

【0027】以上のような入出力関係にある実施形態のエコーキャンセラ1は、ブロックサイズ制御部101と、内部状態更新部102と、適応フィルタ部103と、加算器Rとからなる。

【0028】適応フィルタ部103は、現時刻tの近端入力信号Ｓｉｎ’（＝y(n)）と、遠端入力信号Ｒｉｎのタップ数分pだけのサンプル値でなる遠端入力信号ベクトルx_n（t）と、直前時刻のタップ係数ベクトルh'_n（t-1）とから、上述した(3)式に従って、現時刻tのタップ係数ベクトルh'_n（t）を形成し（エコーパスの伝達特性を推定し）、そのタップ係数ベクトルh'_n（t）と、遠端入力信号ベクトルx_n（t）とから、(2)式に従って、疑似エコー信号ＥＲを生成するものである。

【0029】なお、この適応フィルタ部103には、後述するように、ブロックサイズ制御部101から、タップ数制御信号ＢＣ（＝ｎ）が与えられており、タップ数制御信号ＢＣ（＝ｎ）に応じた次元のタップ係数ベクトルh'_n（t）を生成するようになされている。ここで、次元を増大させる場合は、後述する(8)式による。

【0030】内部状態更新部102には、遠端入力信号Ｒｉｎ（タップ数分nだけのサンプル値でなる遠端入力信号ベクトルx_n（t））が入力されており、この遠端入力信号ベクトルx_n（t）と、内部保有している直前時刻t－1における内部状態変数行列P_n(t-1)及び忘却係数（スカラー量）λとから、(4)式に従って、現時刻tでのゲインベクトルk_n（t）を形成するものであり、また、遠端入力信号ベクトルx_n（t）と、更新されたゲインベクトルk_n（t）と、直前時刻t－1における状態遷移行列P_n（t-1）と、忘却係数λとから、(5)式に従って、現時刻tにおける内部状態変数行列P_n（t）を形成するものである。形成された現時刻tでのゲインベクトルk_n（t）及び内部状態変数行列P_n（t）は、当該内部状態更新部102に内部保有されると共に、ゲインベクトルk_n（t）は、適応フィルタ部103に与えられる。

【0031】なお、この内部状態更新部102にも、後述するように、ブロックサイズ制御部101から、タップ数制御信号ＢＣ（＝ｎ）が与えられており、タップ数制御信号ＢＣ（＝ｎ）に応じた次元のゲインベクトルk_n（t）及び内部状態変数行列P_n（t）を生成するようになされている。ここで、内部状態変数行列P_n（t）の次元を増大させる場合は、後述する(7)式による。また、ゲインベクトルk_n（t）の次元は、内部状態変数行列P_n（t）の次元や、遠端入力信号ベクトルx_n（t）の次元が増大されると、増大されるものである。

【0032】ブロックサイズ制御部101は、遠端入力信号Ｒｉｎ及び又は近端入力信号Ｓｉｎ’の入力状態から、当該エコーキャンセラ1を初期化する必要があるか否かを判断し（言い換えると、各種のベクトルや行列h'_n（t）、k_n（t）、P_n（t）を初期化する時期を判断し）、初期化する必要がある場合には、タップ数を規定するタップ数制御信号ＢＣ（＝ｎ）を1に初期化させた後、時刻tが更新される毎にタップ数制御信号ＢＣを1インクリメントし、タップ数制御信号ＢＣが予め設定された最大タップ数pに達した後は、時刻が経過しても、タップ数制御信号ＢＣの値を最大タップ数pに維持させるものである。以上のように、初期化直後においてのみ時刻の経過に伴って更新されるタップ数制御信号ＢＣは、内部状態更新部102及び適応フィルタ部101へ出力される。

【0033】加算器Rは、エコーＥＴが重畳されている近端入力信号Ｓｉｎ’から、適応フィルタ部103からの疑似エコー信号ＥＲを減算してエコーを消去するものである。

【0034】以上のような各部からなるこの実施形態のエコーキャンセラ1は、全体を通しては、図2のフローチャートに示すように動作する。なお、図2における処理ループは、各時刻で1回処理されるものである。

【0035】新たな時刻tになるとまず、ブロックサイズ制御部101によって、例えば、遠端入力信号Ｒｉｎと近端入力信号Ｓｉｎ’とが監視され、両者の関係から動作モードが判断される（ステップＳ1）。例えば、遠端入力信号及び近端入力信号、又は、両信号のどちらか一方が一定時間入力されない状況（音声レベルに達して

いない状況）にあるか否かにより、疑似エコー信号ＥＲを生成する適応動作の初期化を行なうか否かを判断する。

【００３６】初期化を行なう場合には、ブロックサイズ制御部１０１から値が１であるタップ数制御信号ＢＣ（＝ｎ）が内部状態更新部１０２及び適応フィルタ部１０３へ出力され、このとき、内部状態更新部１０２は、(6) 式に示すように、直前時刻ｔ－１の内部状態変数行列P_n (t-1) を初期パラメータα（固定値）だけを有する１×１の行列に設定する（ステップＳ２）。

【００３７】

$$P_n(t-1)=\alpha \quad \cdots(6)$$

これに対して、ステップＳ１の判断で初期化が不要であるという結果を得ると、ブロックサイズ制御部１０１は、今までのタップ数制御信号ＢＣ（＝ｎ）が既に最大タップ数ｐに達しているか否かを確認し、達していなければ、１インクリメントしたタップ数制御信号ＢＣ（＝ｎ）を内部状態更新部１０２及び適応フィルタ部１０３へ出力して次元の拡大処理を実行させ、一方、最大タップ数ｐに達していると、最大タップ数ｐのタップ数制御信号ＢＣ（＝ｎ）を内部状態更新部１０２及び適応フィルタ部１０３へ出力して次元の拡大処理を実行させないようにさせる（ステップＳ３）。

【００３８】ここで、１インクリメントされたタップ数制御信号ＢＣ（＝ｎ）が与えられた内部状態更新部１０２は、直前時刻ｔ－１の内部状態変数行列P_n (t-1) を、(7) 式に従って、次元が１だけ大きい行列に更新し、また、１インクリメントされたタップ数制御信号ＢＣ（＝ｎ）が与えられた適応フィルタ部１０３は、直前時刻ｔ－１のタップ係数ベクトルh'_n (t-1) を、(8) 式に従って、次元が１だけ大きい行列に更新する。

【００３９】

【数５】

$$P_n(t-1)=\begin{pmatrix}\alpha & 0\\ 0 & P_{n-1}(t-1)\end{pmatrix} \quad ---(7)$$

$$h'_n(t-1)=\begin{pmatrix}0\\ h'_{n-1}(t-1)\end{pmatrix} \quad ---(8)$$

その後、次元の拡大動作の実行の有無を問わず、内部状態更新部１０２によって、上述した(4) 式及び(5) 式に従って、現時刻ｔでのゲインベクトルk_n (t)及び内部状態変数行列P_n (t) が形成される（ステップＳ４）。続いて、適応フィルタ部１０３において、上述した(3) 式に従って、現時刻ｔでのタップ係数ベクトルh'_n (t) が形成される（ステップＳ５）。なお、これらの演算処理時に利用される遠端入力信号ベクトルx_n (t) の次元も、当然に、そのときのタップ数制御信号ＢＣ（＝ｎ）の値による。

【００４０】そして、適応フィルタ部１０３において、上述した(2) 式に従って、現時刻ｔでの疑似エコー信号ＥＲが形成され、加算器Ｒにおいて、疑似エコー信号ＥＲの減算によるエコー消去動作が実行される（ステップＳ６）。

【００４１】このようにして現時刻ｔでの一連の処理が終了すると、ステップＳ１に戻って、次の時刻（ｔ＝ｔ＋１）の処理に進むことになる。

【００４２】以上のような図２に示す処理により、初期化が必要となったときには、有効タップ数が１での適応動作を実行し（Ｓ１、Ｓ２、Ｓ４～Ｓ６）、その後、最大タップ数ｐに達するまで有効タップ数を時刻毎に１ずつ増大させた適応動作を実行し（Ｓ１、Ｓ３（タップ数の更新を伴う）、Ｓ４～Ｓ６）、最大タップ数ｐに達した以降はそのタップ数ｐでの適応動作を実行する（Ｓ１、Ｓ３（タップ数を更新せず）、Ｓ４～Ｓ６）。

【００４３】上記実施形態によれば、内部状態更新部と適応フィルタ部の操作について、適応動作を再度やり直す初期化開始時点からタップ数を逐次増加させるようにしたので、エコーパスの伝達特性へ追従し直す適応動作の初期化時における演算量を削減することができる。

【００４４】また、エコーパスのインパルス応答が比較的短い場合には、このように演算量を削減しても、タップ係数をより速くエコーパスの伝達特性に収束させることができる。

【００４５】さらに、適応フィルタ部のタップ係数等の各種パラメータは、タップ数が増加された際にも、次の時刻へ継承されるため、収束動作がとぎれることなく、速やかな収束動作を実現することができる。

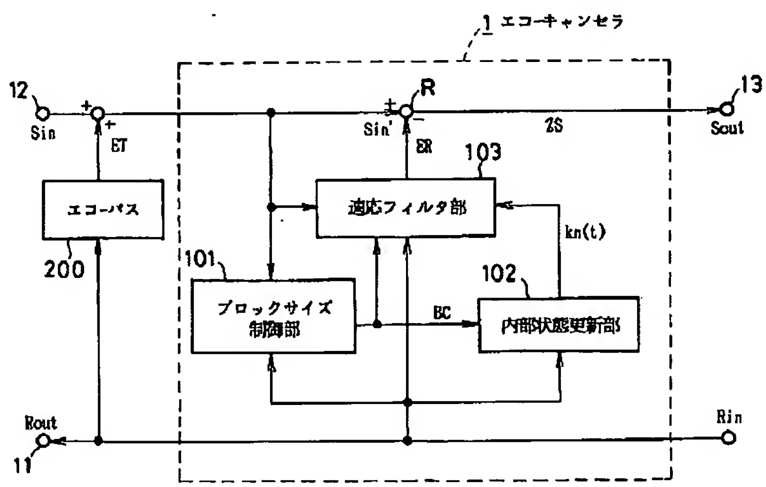
【００４６】なお、上記実施形態においては、ＲＬＳ法に適用したエコーキャンセラを示したが、タップ数に応じた次元を有するベクトルや行列等で表される時刻毎に逐次更新される内部状態量を利用して、タップ係数（ベクトル）を形成するアルゴリズムを採用しているエコーキャンセラであれば、本発明を適用することができる。例えば、カルマンフィルタ法や学習同定法等を利用したエコーキャンセラに本発明を適用することができる。

【００４７】また、上記実施形態においては、ハイブリッド回路のインピーダンス不整合によるエコーを消去するエコーキャンセラを想定しているが、スピーカからマイクロホンへ回り込んだエコーを消去するエコーキャンセラに本発明を適用することができる。

【0048】
【発明の効果】以上のように、本発明によれば、内部状態更新部と適応フィルタ部の操作について、適応動作を再度やり直す初期化開始時点からタップ数を逐次増加させるようにしたので、エコーパスの伝達特性へ追従し直す適応動作の初期化時における演算量を削減でき、また、エコーパスのインパルス応答が比較的短い場合など、タップ係数をより速くエコーパスの伝達特性に収束させることができる。

【図面の簡単な説明】
【図1】実施形態の構成を示す機能ブロック図である。
【図2】実施形態の動作を示したフローチャートである。
【符号の説明】
1…エコーキャンセラ、101…ブロックサイズ制御部、102…内部状態更新部、103…適応フィルタ部、R…加算器。

【図1】



【図2】